University of California at Berkeley
Physics 129A
Professor Freedman
Fall 2004
September 12, 2004
Homework #2 (Due: Friday September 17)

1. Specify the additional particles required to maintain lepton number conservation in the following weak processes:

i. $\mu^- \to e^- + \ ?$

ii. $\tau^- \to e^- + \ ?$

iii. $e^- + {}^{A}X^{Z} \to ?$

iv. $\nu_\mu + n \to ?$

v. ${}^{A}X^{Z} \to {}^{A}Y^{Z-1} + ?$

vi. $\bar{\nu}_e + p \to ?$

2. Consider the elastic scattering of two protons. One is initially at rest in the laboratory and for simplicity we assume that the two particles travel symmetrically at equal angles to the incident particle momentum after the collision. Show that the angle between the outgoing particles (call it θ) decreases as the energy of the incident particle increases (take the incident particle energy as ($E_i = E_o + K_i$, $E_o = mc^2$). Show that $\cos\theta = K_i / (4E_o + K_i)$.
F. C. Champion first experimentally verified the relativistic compression of the scattering angles in 1932 with electrons (F. C. Champion, Proc. Roy. Soc. (London) A 136, 630 (1932).

3. Find the relativistic threshold energies for the following reactions, assuming the target proton is stationary:

(a) $p + p \to p + p + p + \overline{p}$

(b) $\pi^- + p \to p + \overline{p} + n$

In the real experiment done to discover the antiproton the target proton was bound inside the nucleus of Be. Estimate how the threshold energy after taking effect of proton being bound inside Be. The momentum of the bound proton is called 'Fermi momentum' and its origin is related to the quantum uncertainty relation.